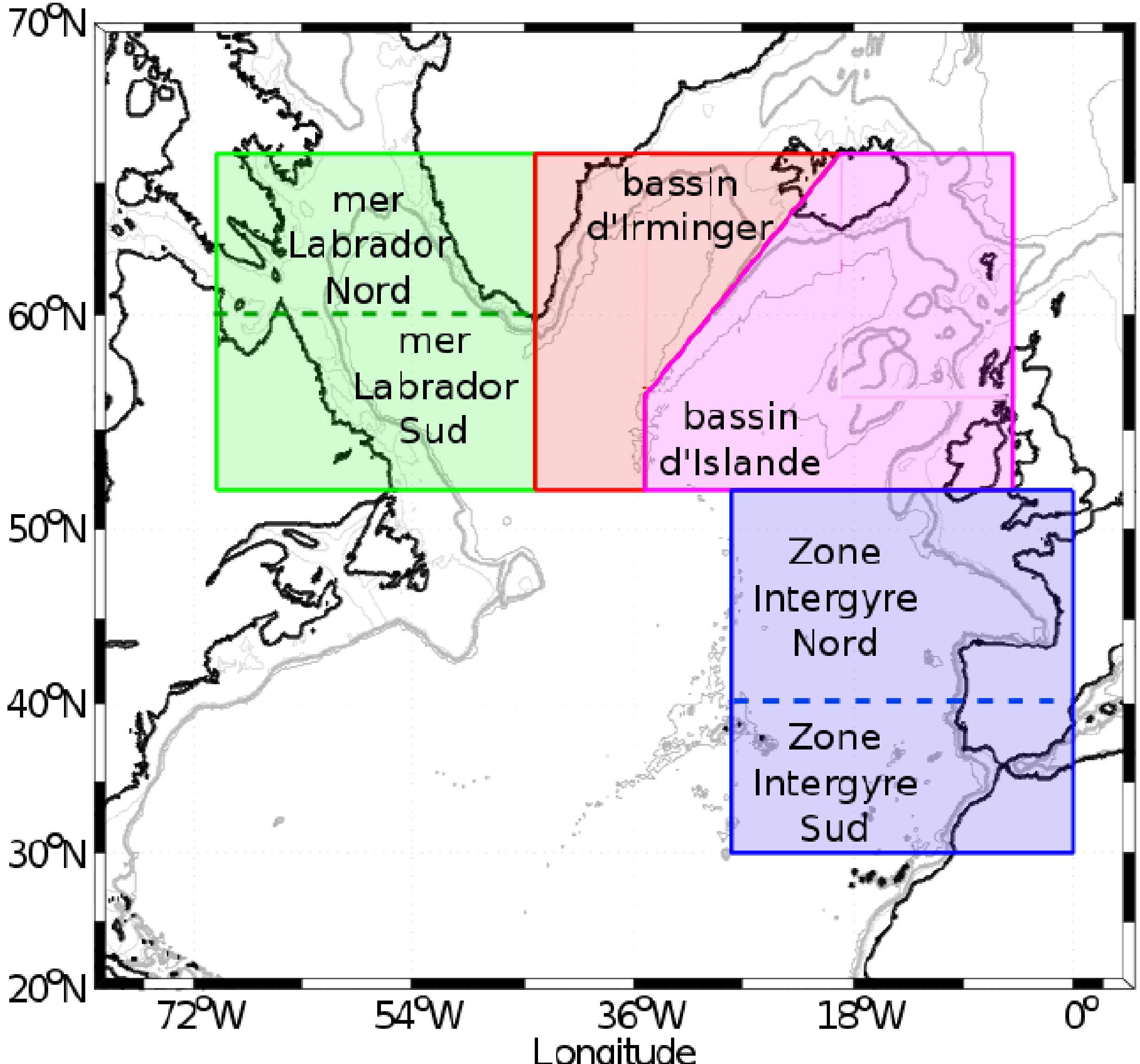
Ocean conditions during winter 2009-2010
Ocean (surface) salinity long time series

G. Reverdin
LOCEAN

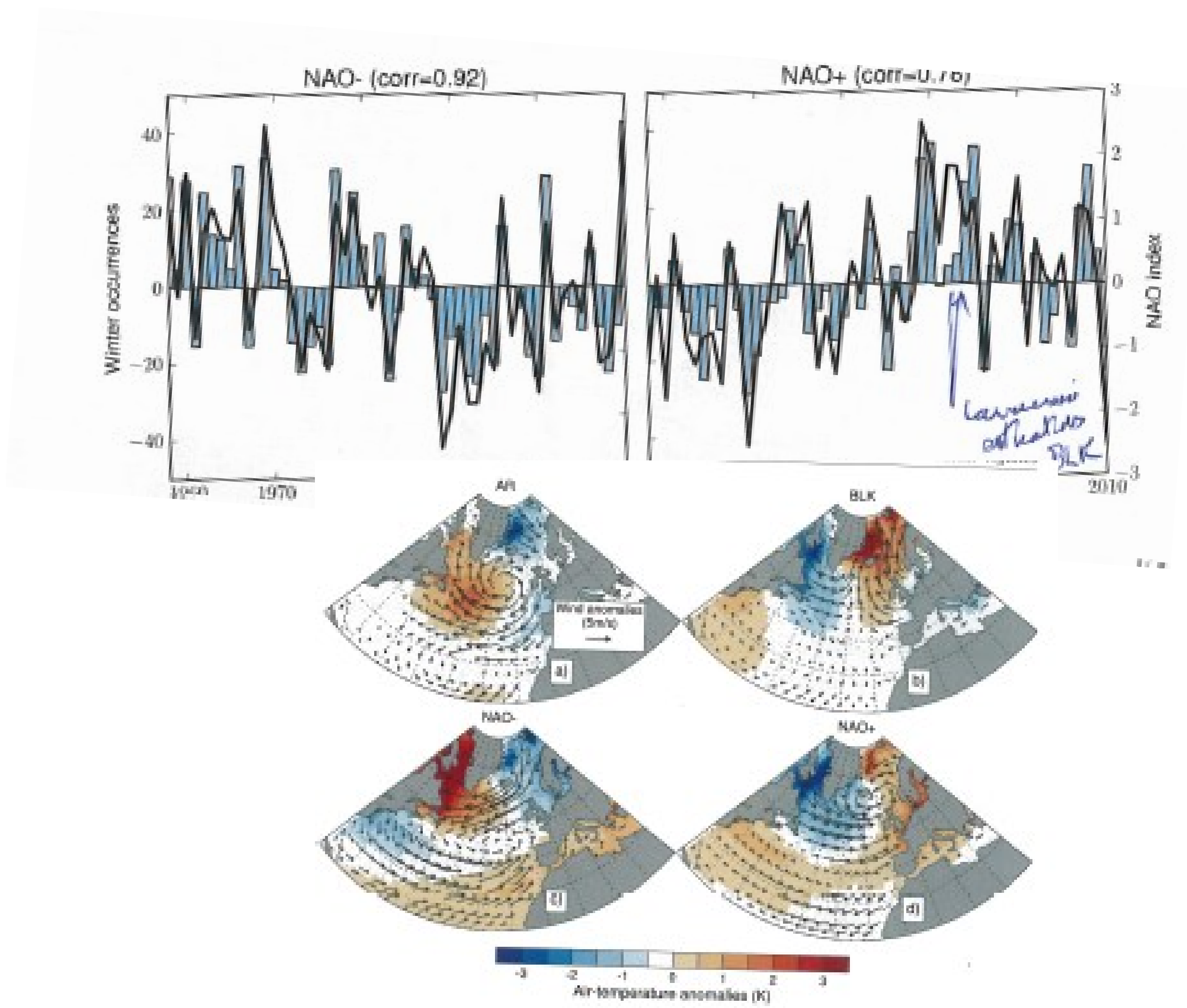
contributions from Elodie Kestenare and SSS group
From Nicolas Kolodziejczyk, Anne Piron, Loïc Houpert for 2009-2010
JL Boone; N. Barrier

Mapped late winter properties
Anne Pirion

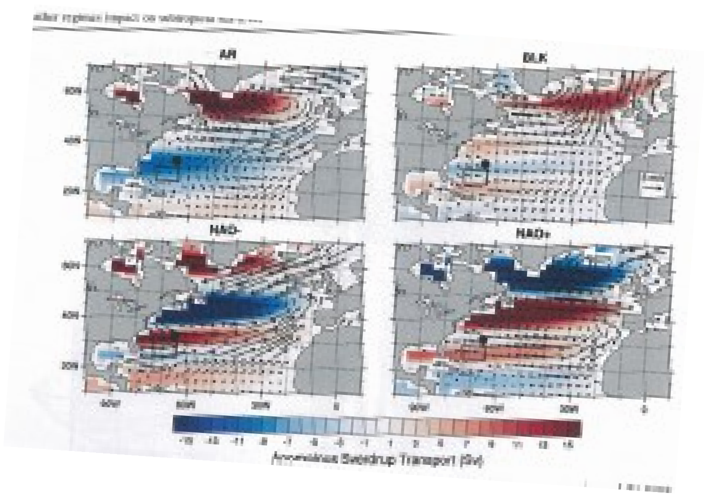


Hiver 2009-2010 NAO-

- NAO- très fort hiver 2009-2010 (N. Barrier)

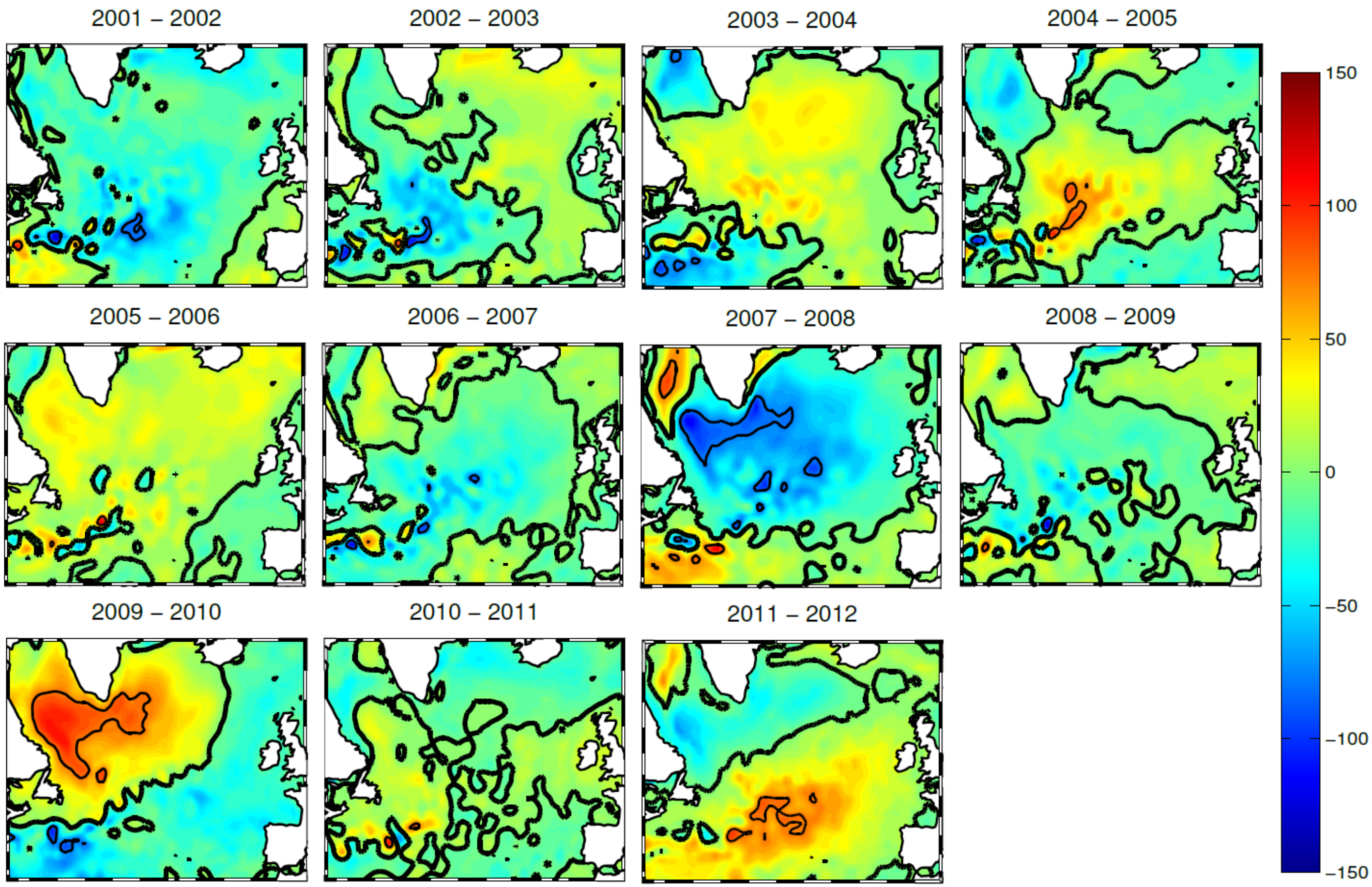


Circulation océanique/niveau de la mer

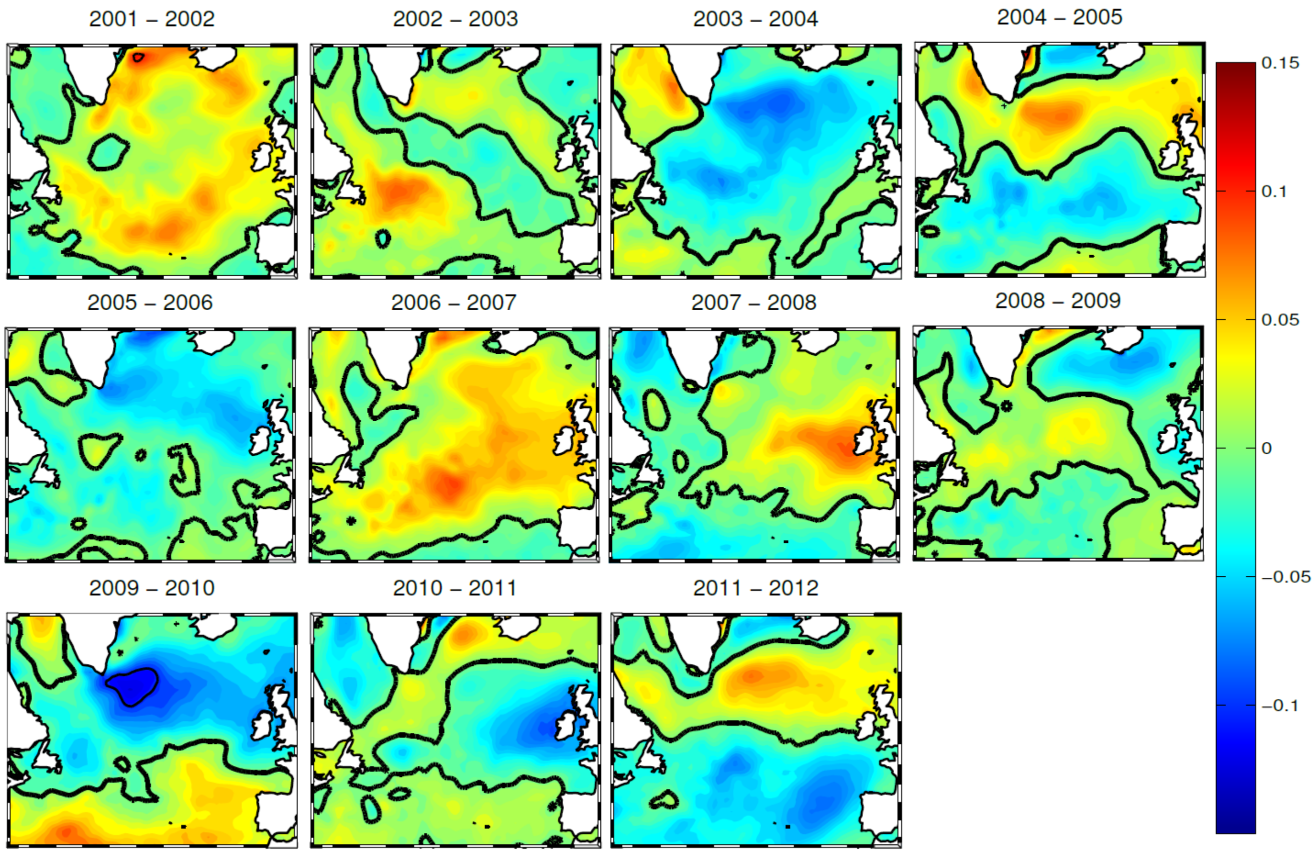


Réponse sur intergyres, mais cœurs du gyre subtropical plus lié au mode AR (N. Barrier)

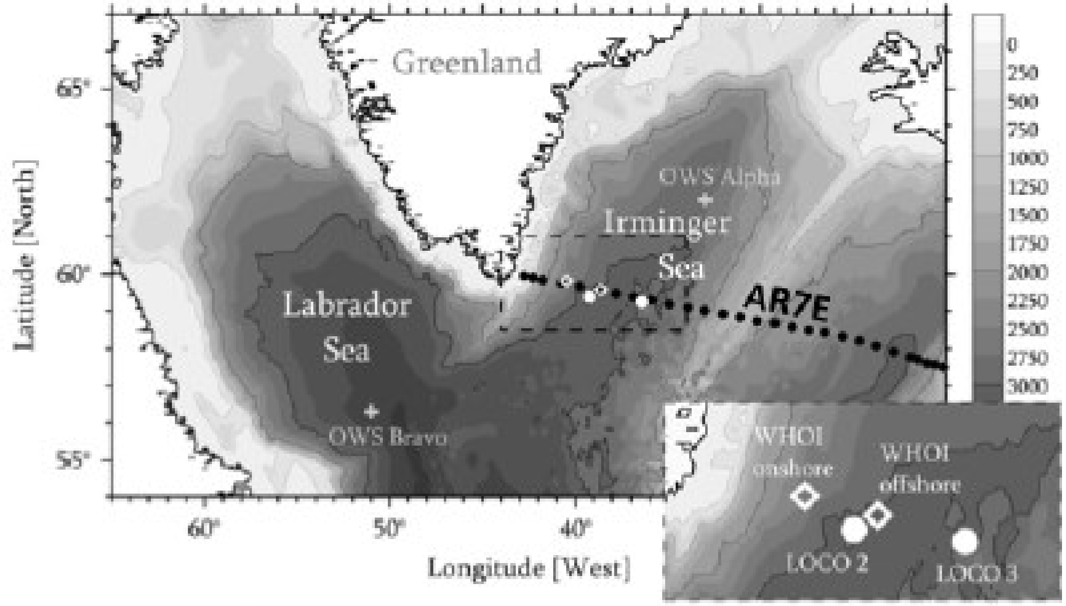
NASG



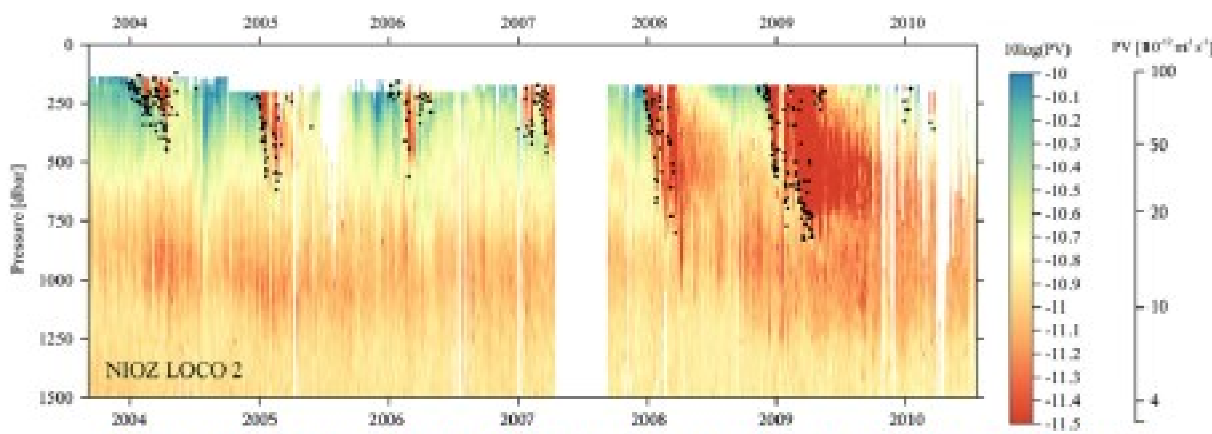
RE 2.5: Anomalies de flux de chaleur nets ($W.m^{-2}$) de décembre à mars par rapport à la période 2002-2012
s noirs épais : isoligne-0 ; traits noirs fins : isolignes -75 et 75 $W.m^{-2}$.



E 2.6: Anomalies de tension de vent ($N.m^{-2}$) de décembre à mars par rapport à la période 2002-2012
noirs épais : isoligne-0 ; traits noirs fins : isolignes -0.1 et 0.1 $N.m^{-2}$



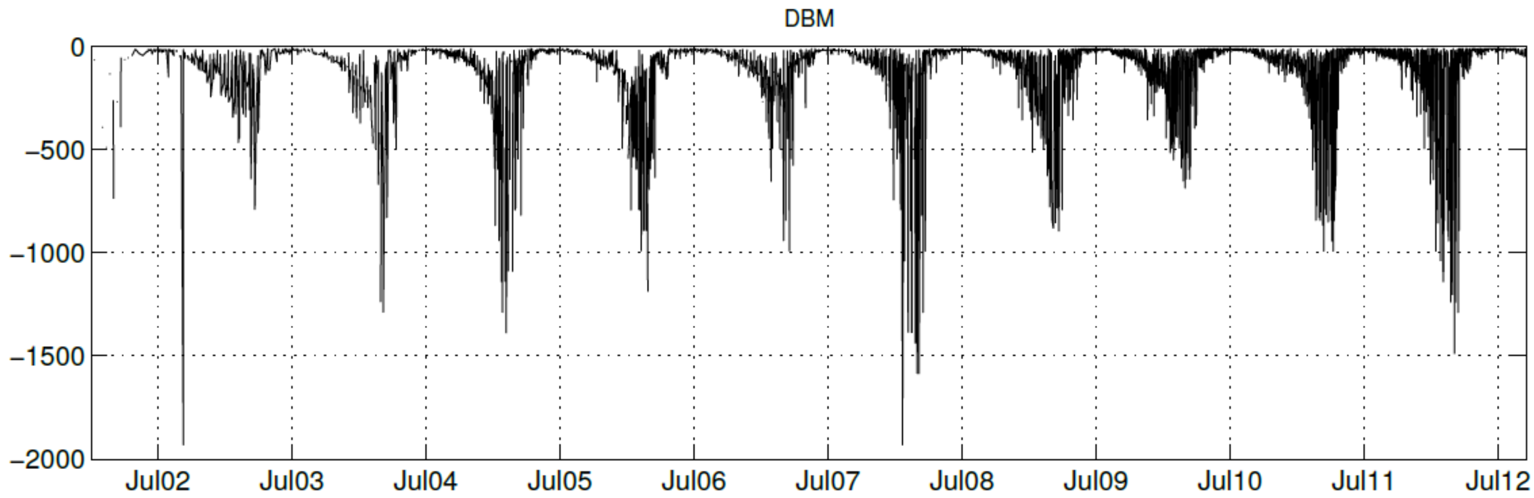
(a) **symboles blancs** : localisation des mouillages LOCO2 et LOCO3 du NIOZ (Royal Netherlands Institute of Sea Research) et des mouillages onshore et offshore du WHOI (Woods Hole Oceanographic Institut) ; **points noirs** : positions de la section AR7E



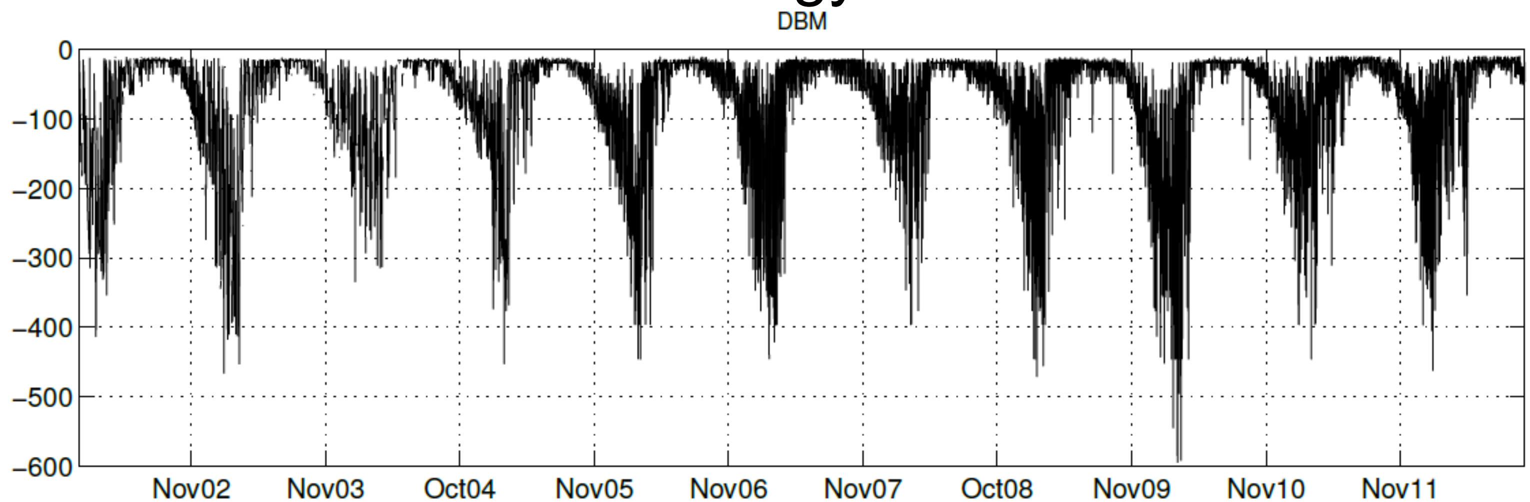
(b) vorticité potentielle et MLD observées au mouillage LOCO2 entre 2004 et 2010.

URE 1.15: observations des couches de mélange dans la mer d'Irminger.[Figure tirée de de Jong et al. (2012)]

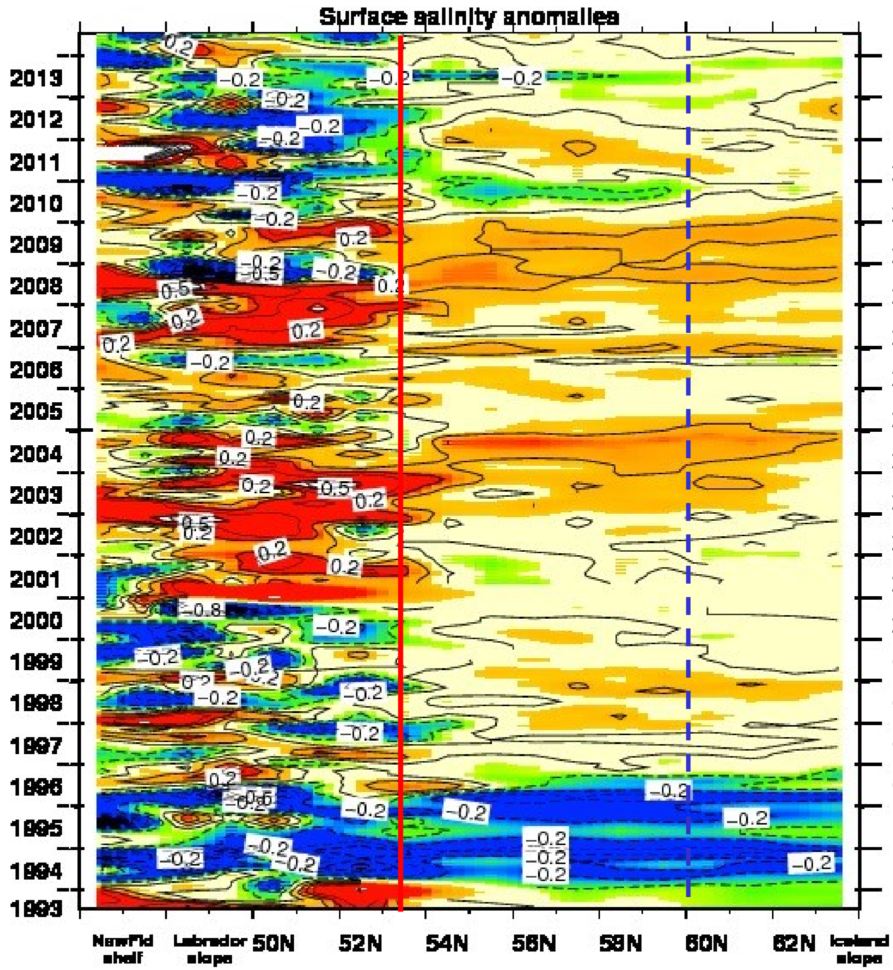
MLD South Labrador Sea

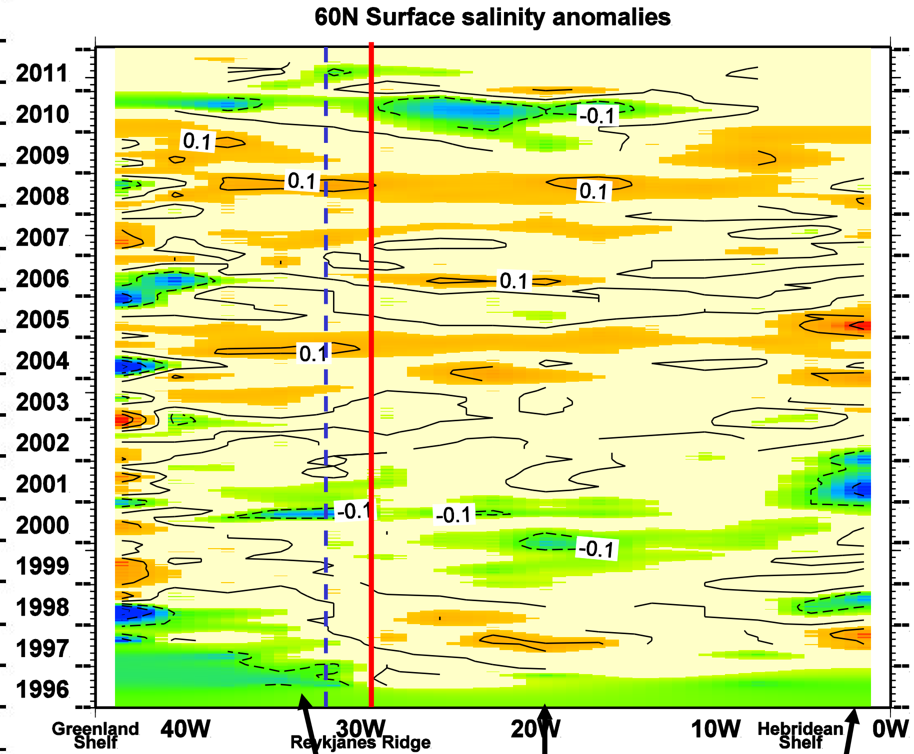


North Inter-gyre



Subpolar gyre (salinity)





Larger signal : circulation

Binning data 1°x1 month :
scales resolved a few degrees and a few months
Large spatial coherence : modulation of gyre

Sub-tropical North Atlantic (N. Kolodziejczyk)

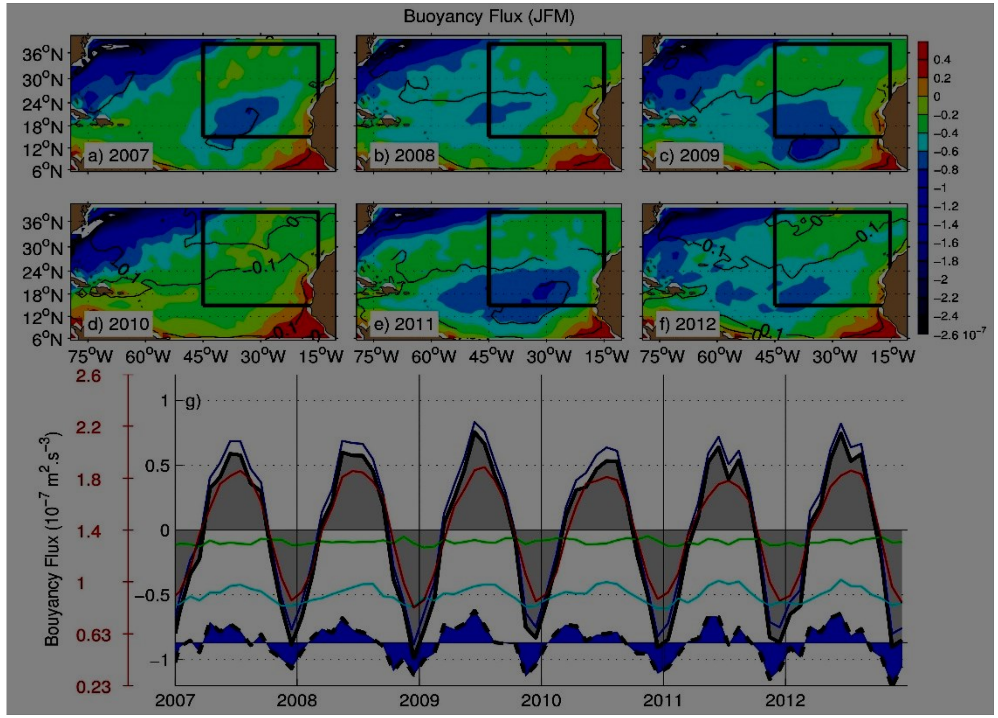
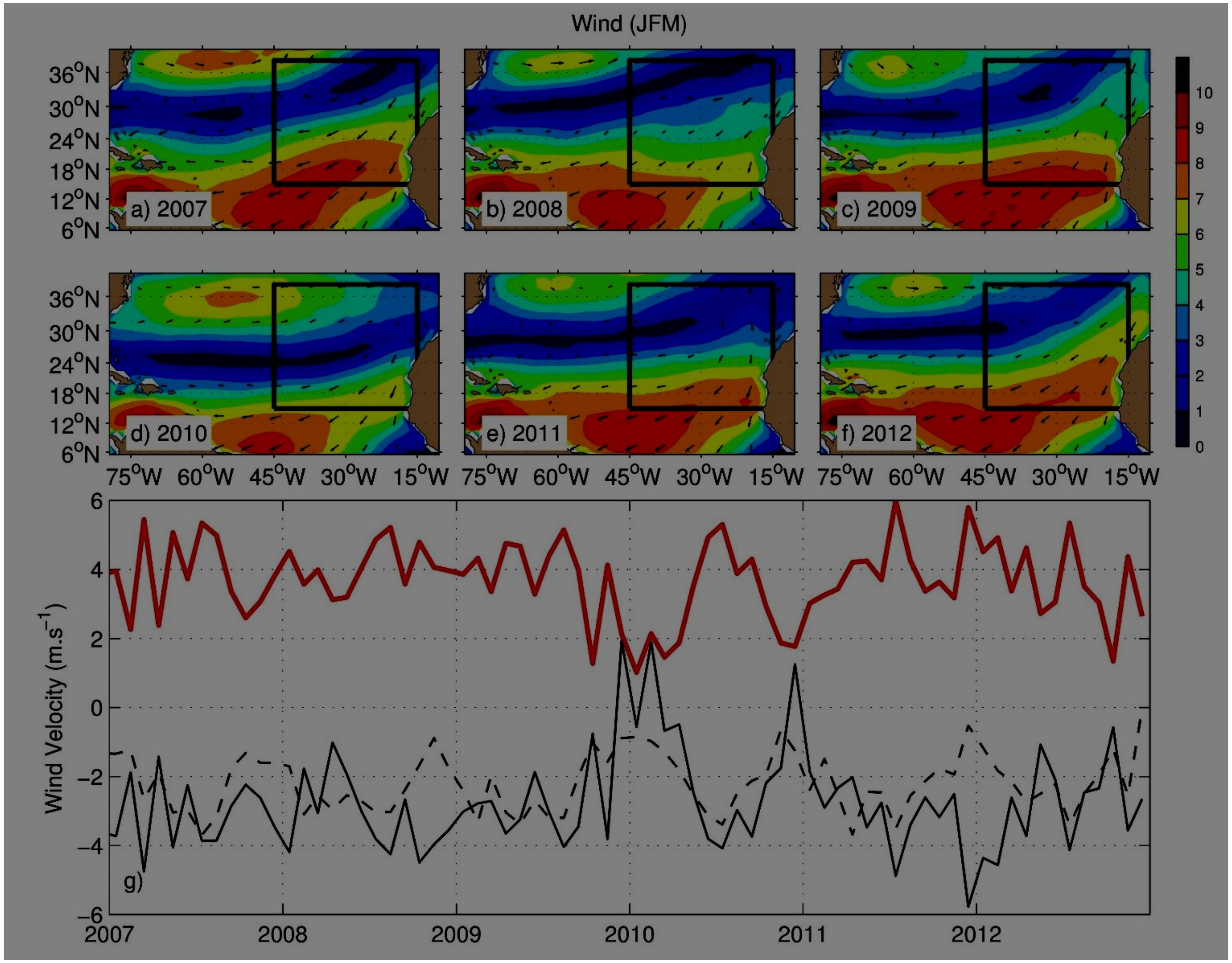


Figure 6: (a-f) Subtropical North Atlantic distribution of mean buoyancy flux (shaded; in m^2s^{-3}) and Evaporation minus Precipitation flux contribution to the buoyancy flux (contours; in 10^{-7} m^2 s^{-3}) during each winter (JFM) between 2007 and 2012. (g) Time series of buoyancy flux (thick black), heat flux contribution (thin blue); E-P flux contribution (thin green), Latent heat flux contribution (dashed thick black and blue); long wave plus sensible heat flux contribution (thin cyan); and shortwave contribution (thin red); note that the shortwave curve (thin red) is shifted in order to facilitate the comparison (red axis).

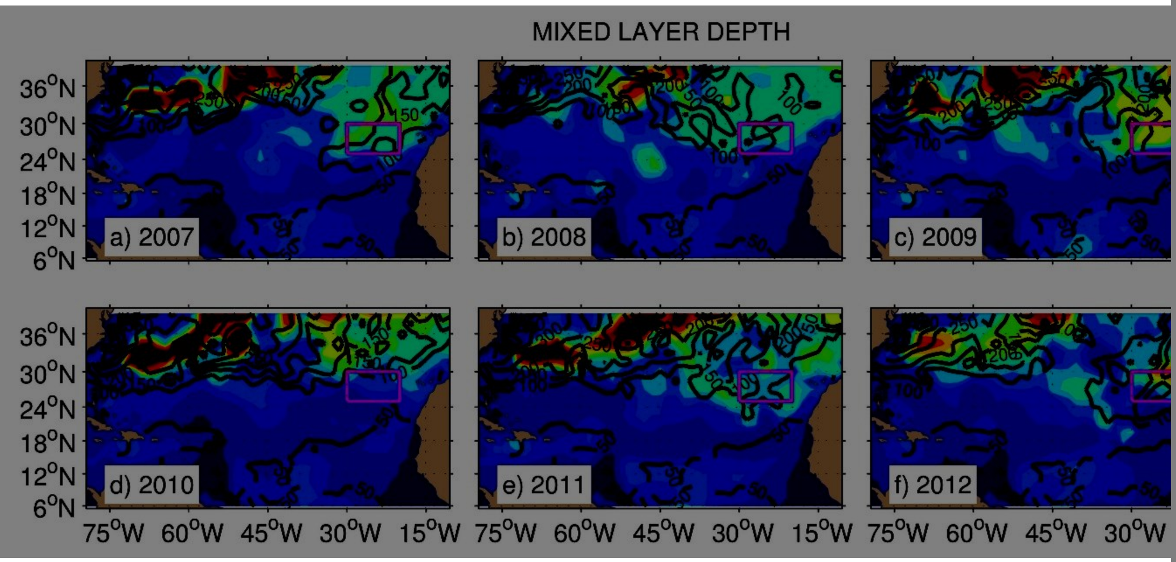
STNA wind

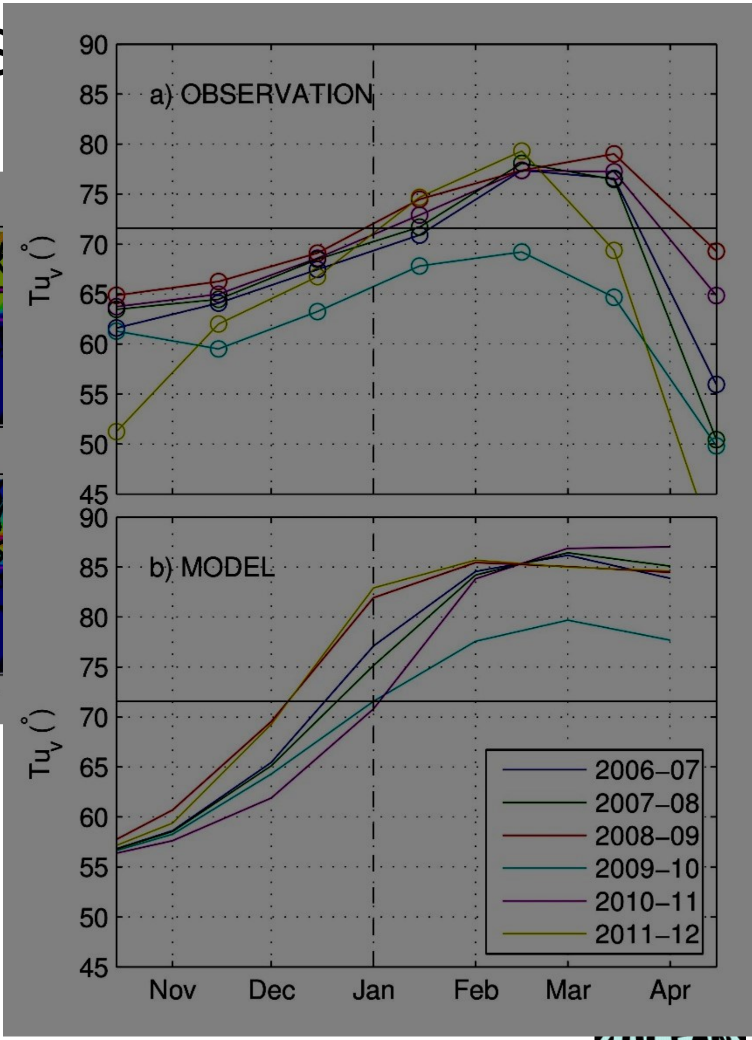


Wind (JFM)
36°N
30°N
24°N
18°N
12°N
6°N
a) 2007
b) 2008
c) 2009
d) 2010
e) 2011
f) 2012
75°W
60°W
45°W
30°W
15°W
0
1
2
3
4
5
6
7
8
9
10
Wind Velocity (m.s⁻¹)
g)
2007
2008
2009
2010
2011
2012

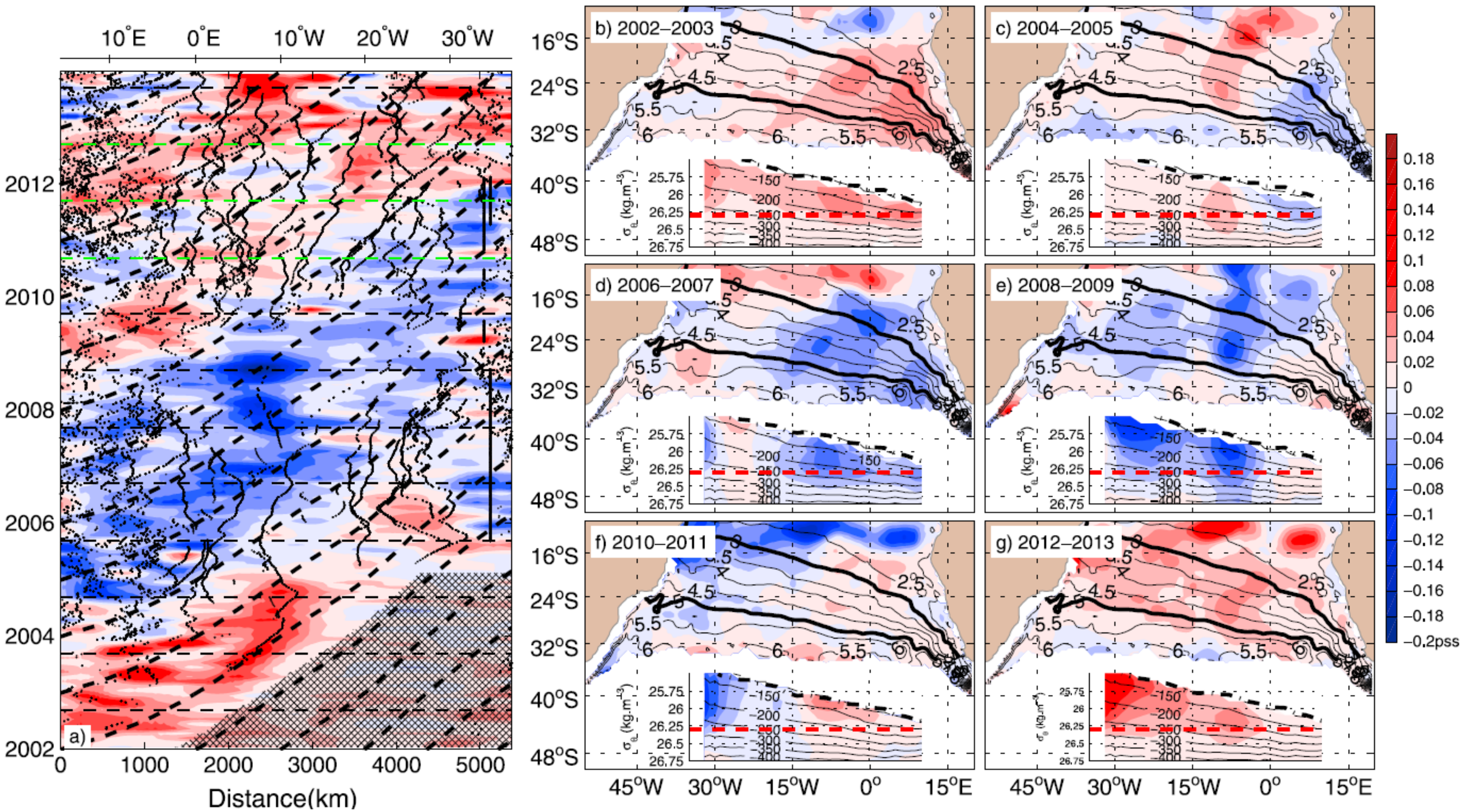
Late winter MLD and vertical Turner angle

Contours (1D model); color shading ISAS





South Atlantic: isopycnal (thermocline) S anomalies (N. Kolodziejczyk)



Gulf of Lion (NW Mediterranean)
L Houpert

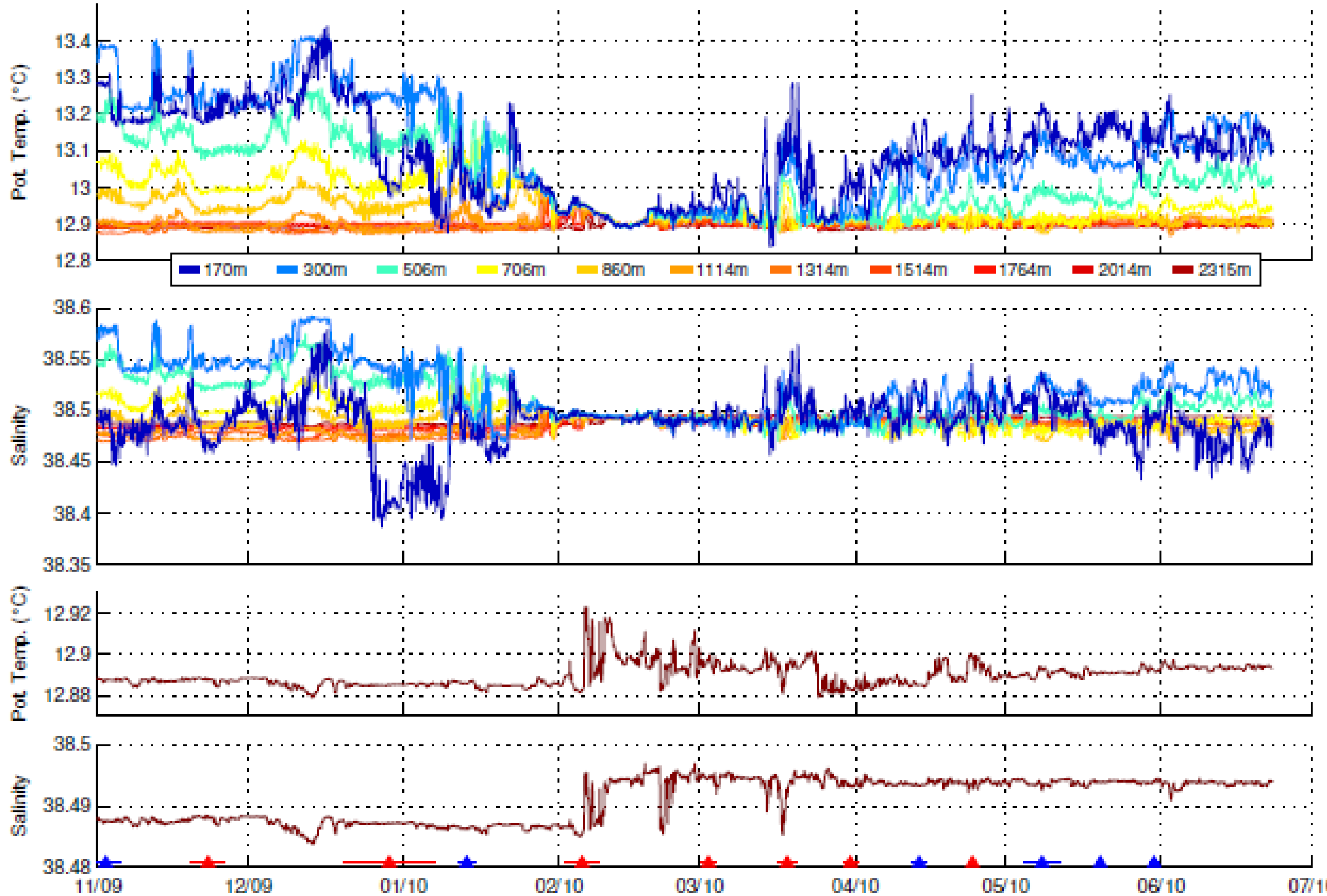


Figure 4.3: Temperature (a) and salinity (b) records at Seabird Microcat depth from 170m (dark blue) to 2330m (dark red) between November 2009 and July 2010. The near-bottom potential temperature (c) and salinity (d) are also presented with a separate vertical scale. Red and blue triangles correspond to the center of cyclones, respectively anticyclones, detected by the method presented in the part 4.3.2, the horizontal line indicating the estimated time period of the event.

Gulf of Lion (NW Mediterranean)
L Houpert

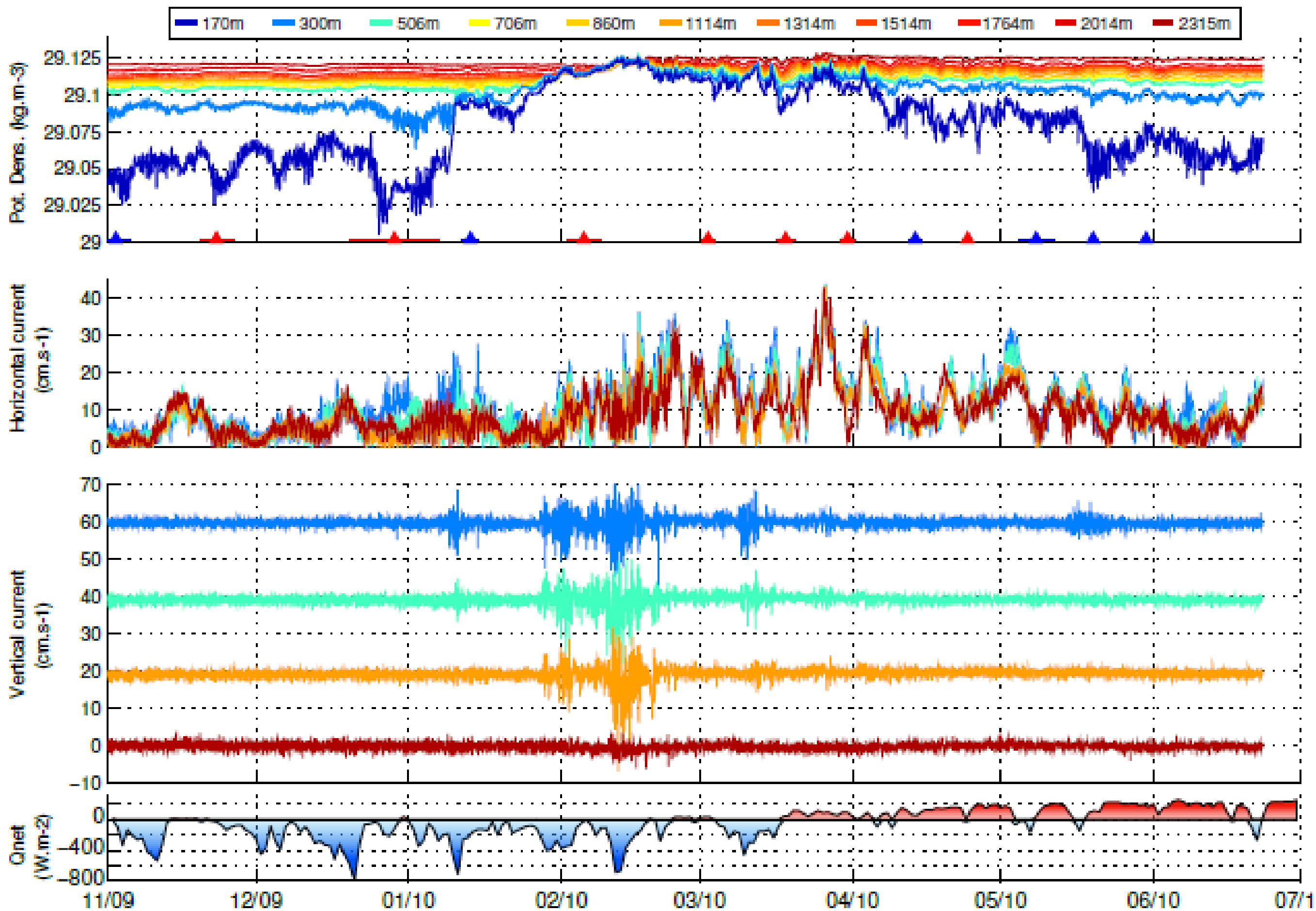


Figure 4.4: Potential density (a) records at Seabird Microcat depth from 170m (dark blue) to 2330m (dark red) between November 2009 and July 2010, with horizontal (b) and vertical (c) currents recorded by the 250m (blue), 500m (green), 1000m (orange) and 2330m (dark red) Aquadopp, and daily net heat flux Q_{net} (d) estimated by Era-Interim at the mooring location. Red and blue triangles on (a) correspond to the center of cyclones, respectively anticyclones, detected by the method presented in the part 4.3.2,

Interannual fluxes/Mixing

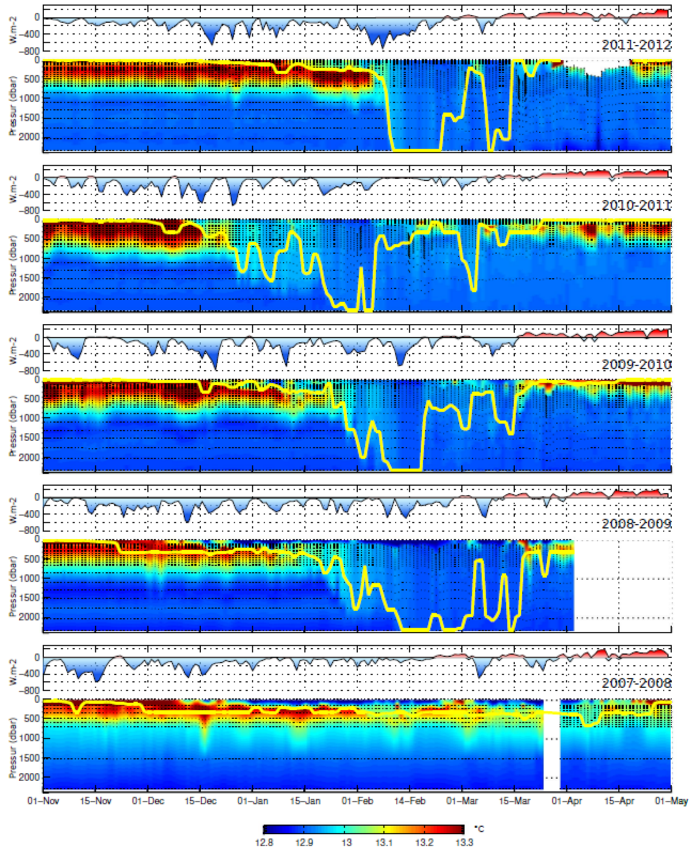


Figure 4.6: 5 years of net atmospheric heat flux from Era-Interim reanalysis and potential temperature with mixed layer depth, coutoured over instruments of the deep LION mooring and the LION surface buoy, from December to May. Black dotted lines show the pressure at the instruments depth. Yellow thick line indicates the mixed layer depth estimated (see the text for a description of criterion chosen)

Long time series of surface salinity (North and tropical Atlantic)

Observations from 1895-2013

(extension from WOD profile data mostly since 1950s)

- Issues of spatial coverage (in particular south of equator before 1950s)
- Issues of biases (little data qualification; need of data corrections)

Salinity: concentration of salt

- Sea water anions and cations in fixed' ratios (Dittmar, 40 samples from the Challenger Expedition1874-1877)
- Thus, to 0-order S=fn(C,T), and

  density=fn(T,S,P)

(small increase 0(0.003 psu) due to increase DIC; small overall decrease due to glacial melt/change of ocean mass)

S evolves with freshwater sources/sinks

(E-P+R); otherwise, conservative tracer

What is measured

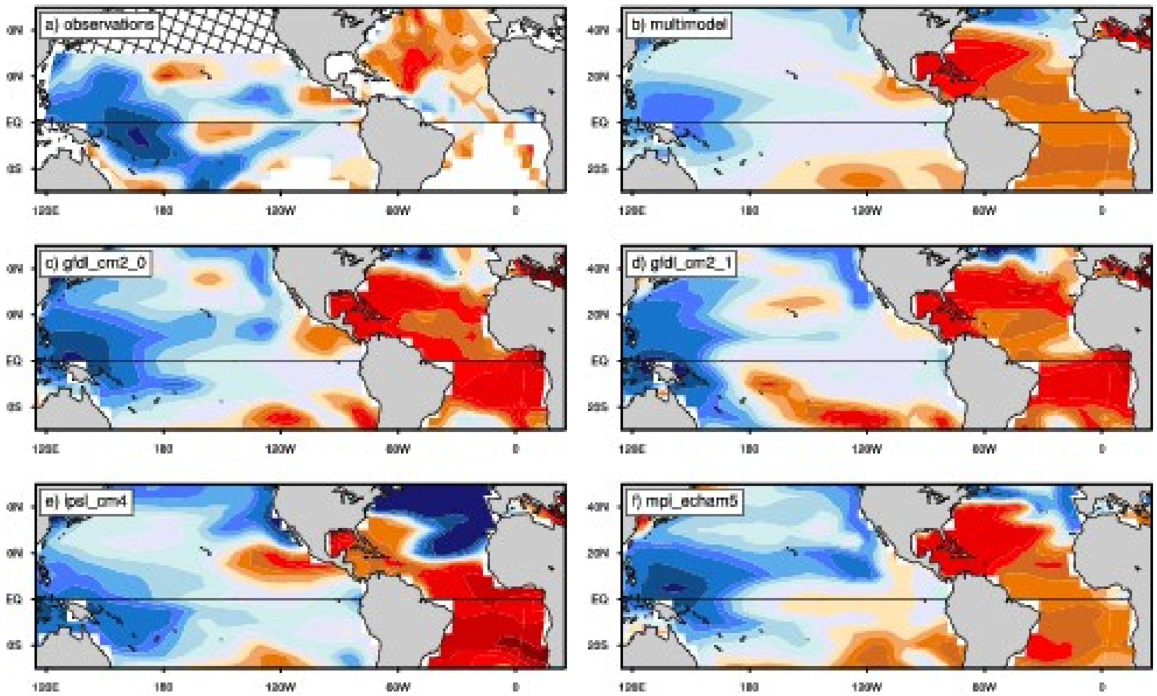
- ‘’concentration of salt’ measured with respect to a standard water

  (consistent since 1900)

- Chlorinity before 1960s;
- Conductivity, since 1970s

Lost in Fathom: London

Trends– natural variability
A climate change perspective



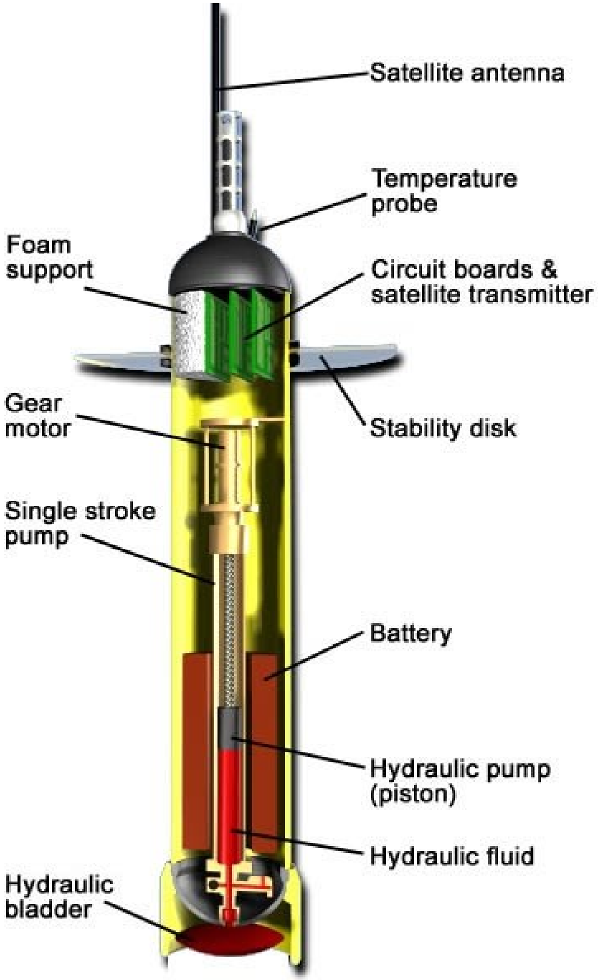
Trend SSS/century in climate models
(compared to obs 1970-2002)
Terray et al 2012; Delcroix et al., 2011; Durack and Wijfells (also subsurface
On 5-10 year time scales since 1960s)

Pacific seems to be robust, but N. Atlantic within natural variability

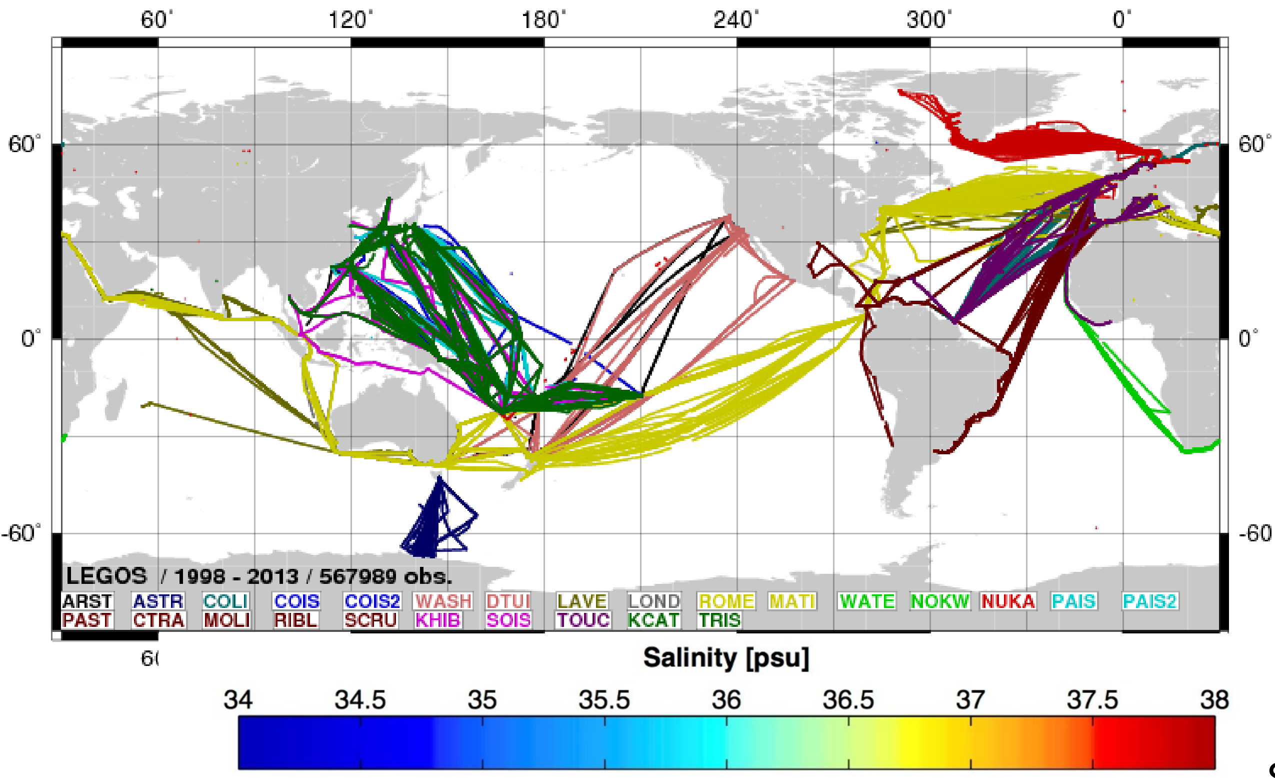
How do we measure it

- Discrete samples 110 y (0.1 psu)
- Thermosalinographs 40 y (ships, drifters) (0.02 psu)

- Argo floats (0.01 psu) (and other profilers)

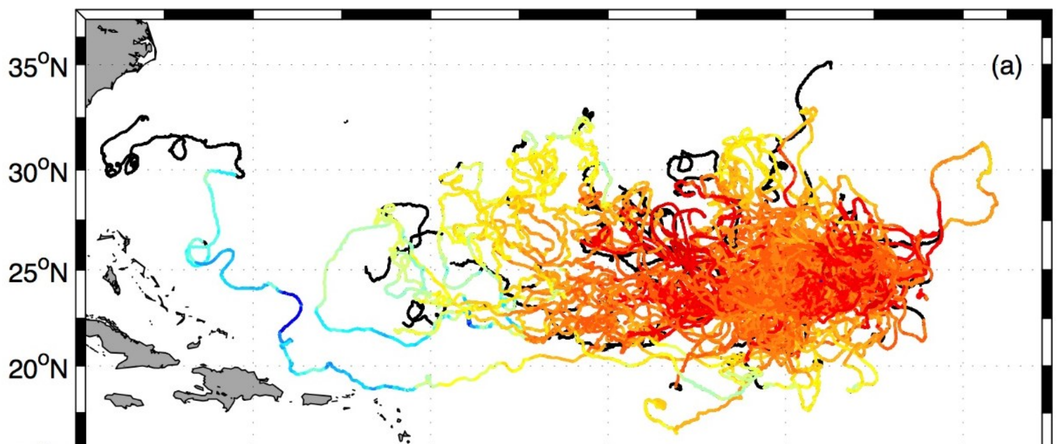


Different networks



SO SSS
G. Alory, T. Delcroix
SOCAT, GOSUD, SAMOS

(all require careful validation)

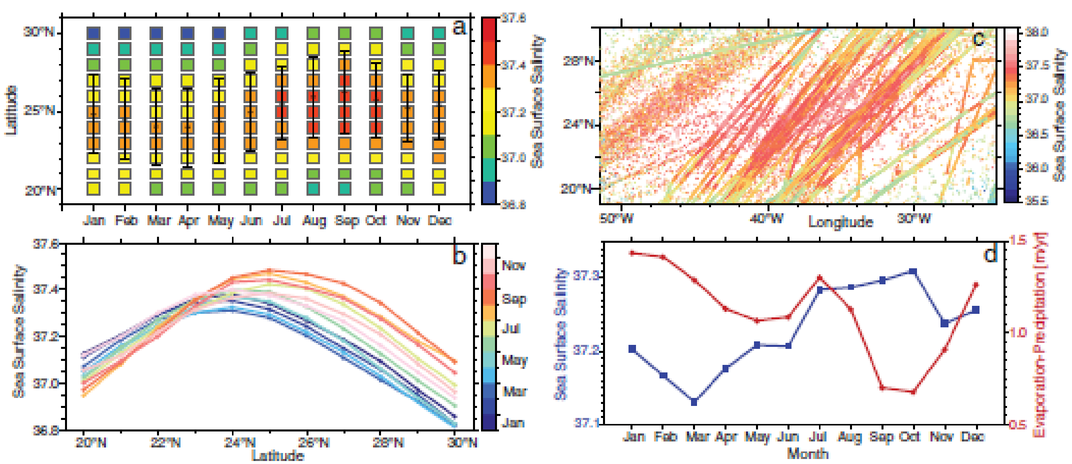


Surface drifters (SPURS)
L. Centurioni, V. Hormann
J. Font, G. Reverdin

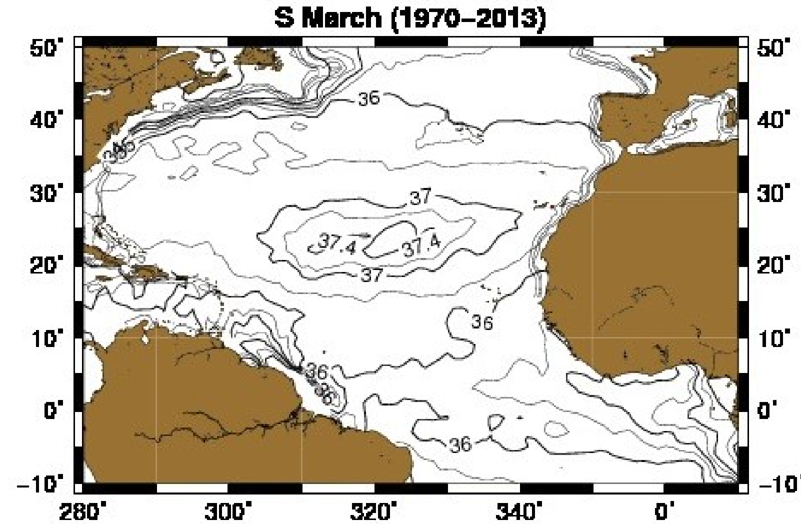
Requires also careful validation)

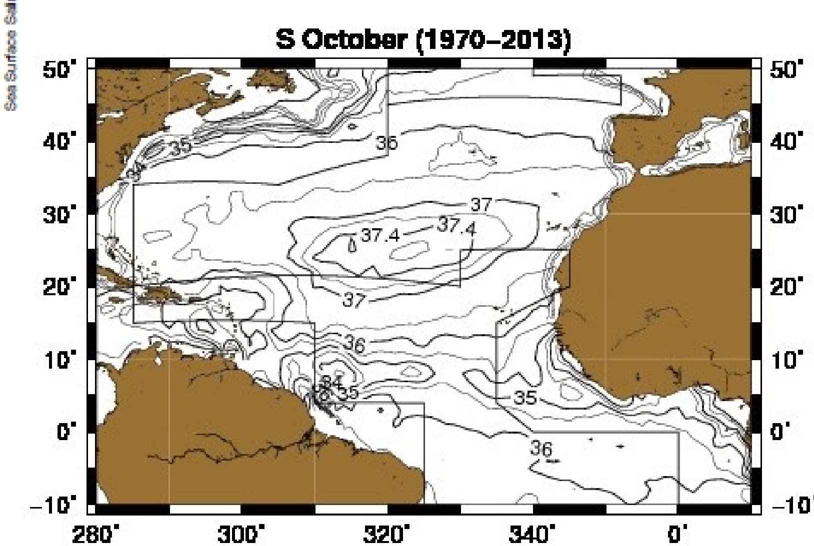
Mapping of climatology

Sufficient data: Last 40 years
Reverdin et al, 2007;
Delcroix et al., 2005



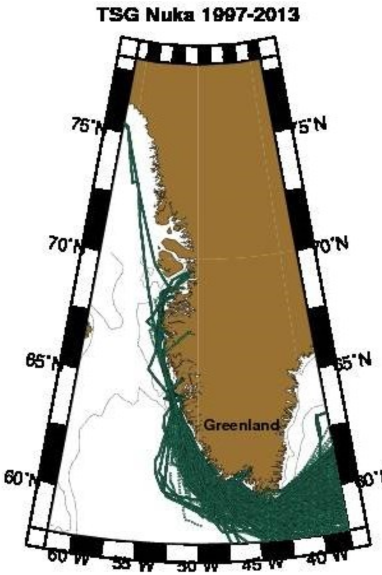
Gordon and Giulivi, 2014

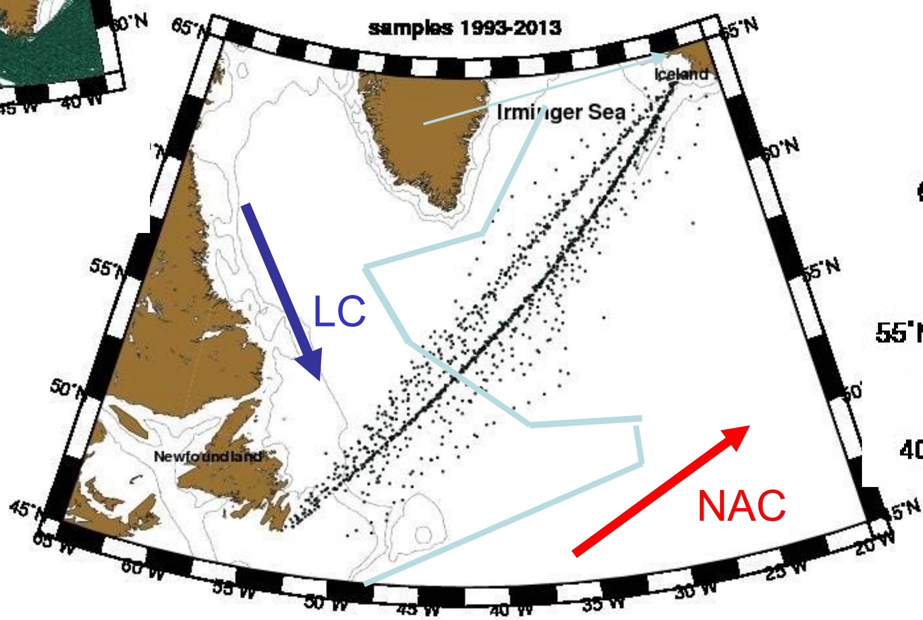


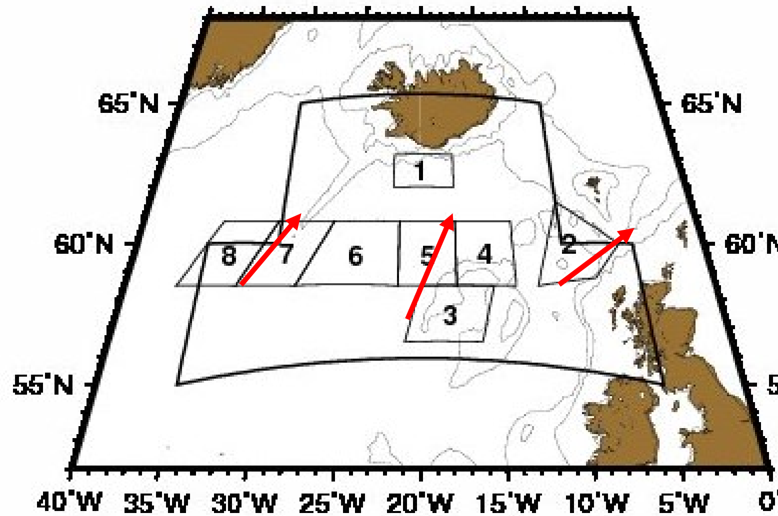


Examples of variability

Binning in boxes or along tracks…

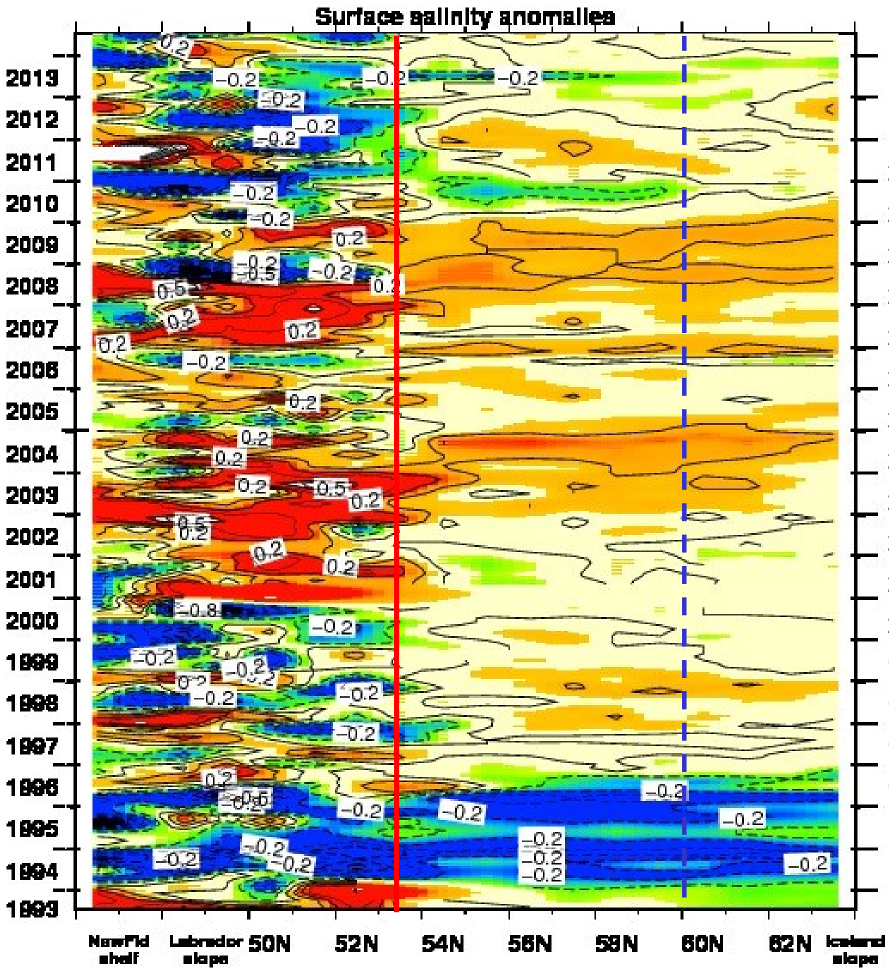


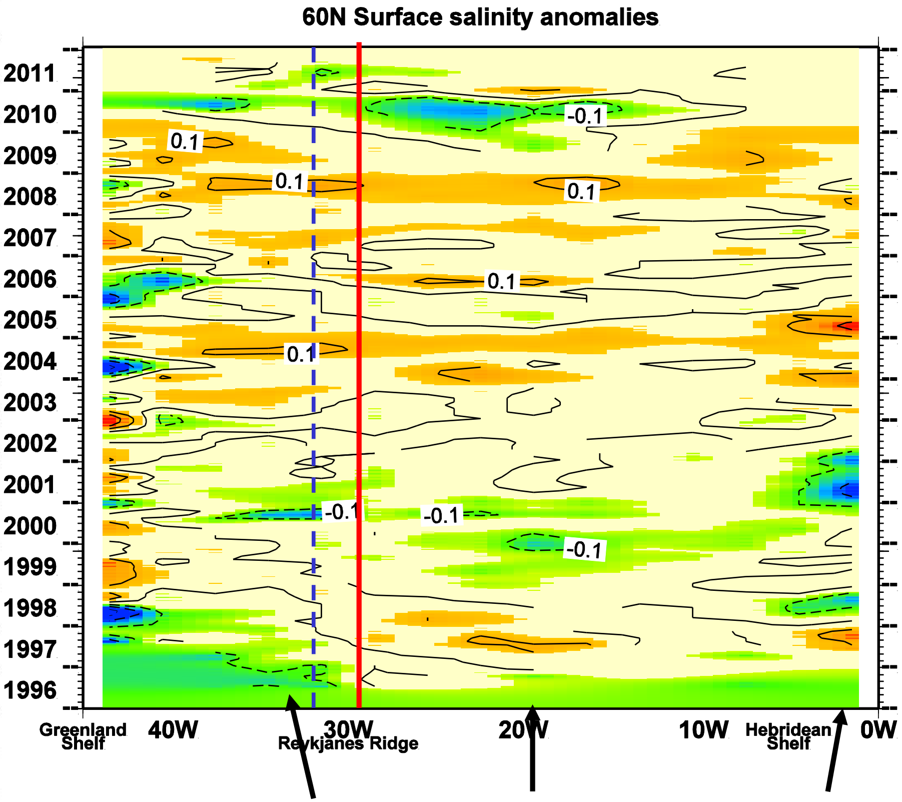




Subpolar gyre : TSGs (20 years)
earlier sampling 100 years

Subpolar gyre

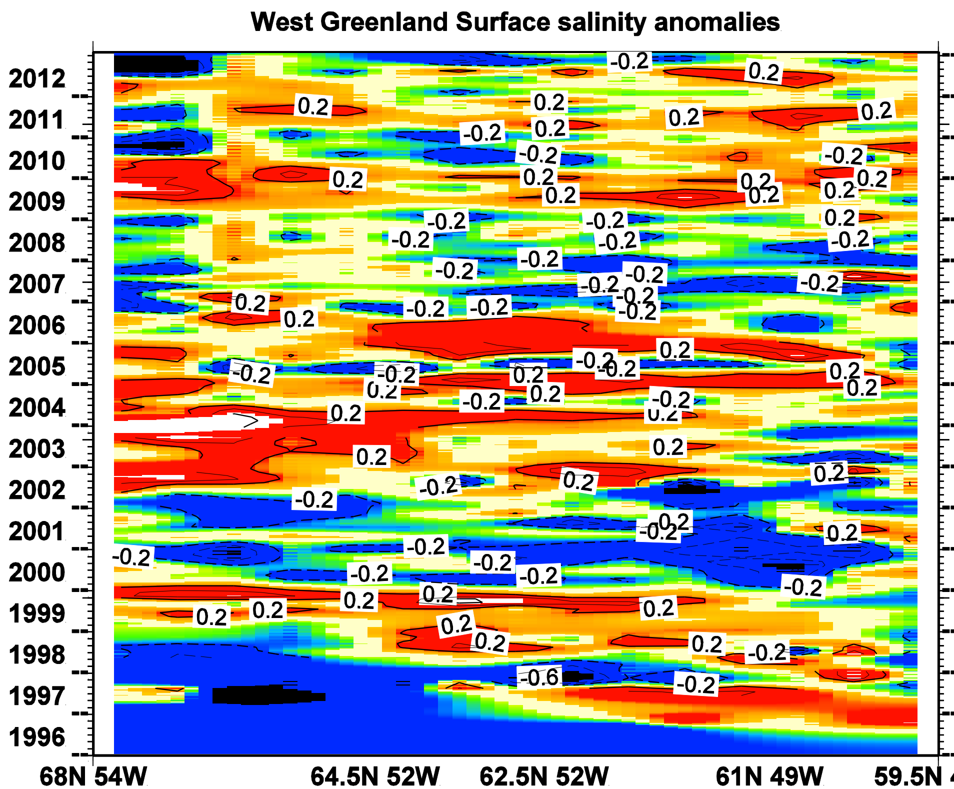


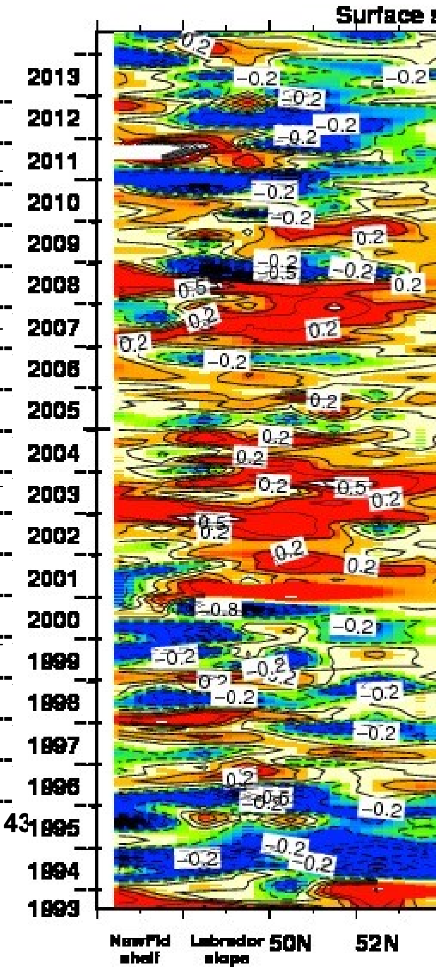


Larger signal : circulation

Binning data 1°x1 month :
scales resolved a few degrees and a few months
Large spatial coherence : modulation of gyre

West Greenland / Nfld shelves

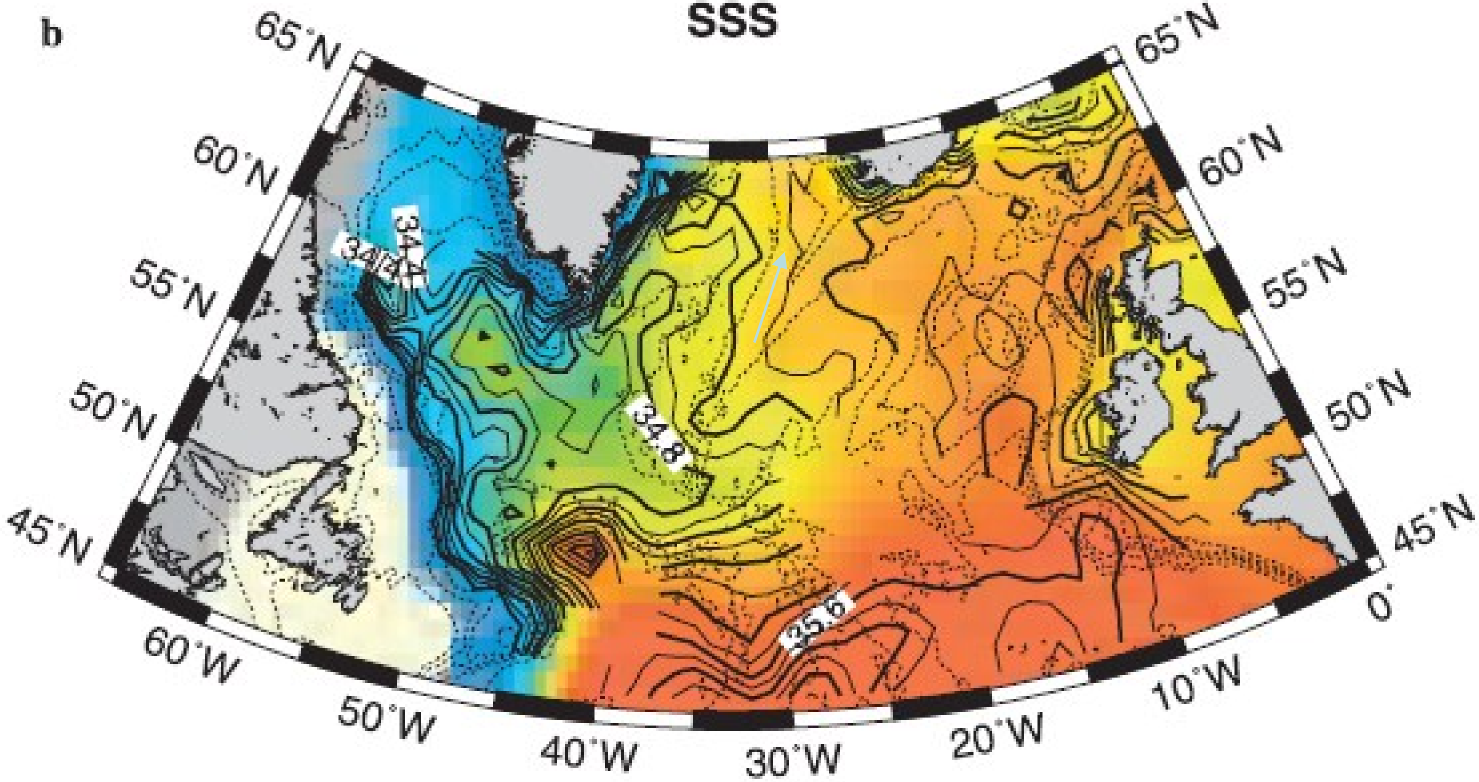




Larger seasonal modulation on shelves; harder to interpret
(for example, expectation of huge melt in 2011-2012, and no low S)
Possible phase opposition West Greenland/ Newfoundland shelf

Spatial mapping of seasonal fields (last 10-50 years)

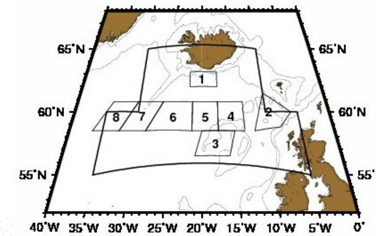
April-June 1997

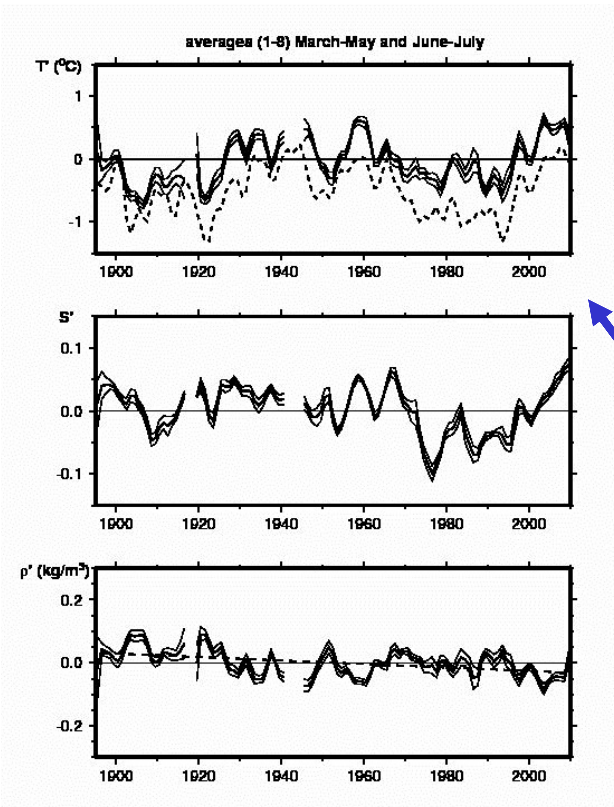


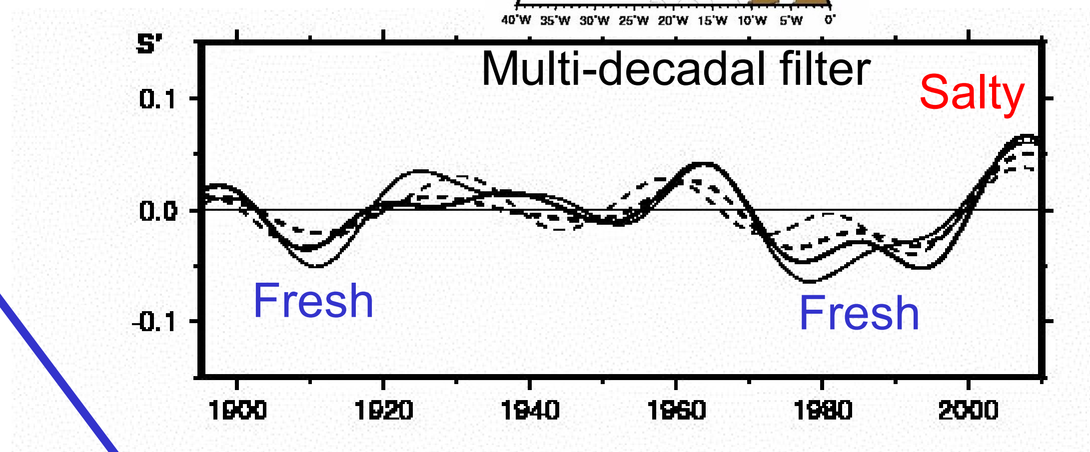
<u>300-500 km scales </u>can be retrieved (away from fronts), even with the spare Argo sampling (and surface TSG sampling)
ISAS (Gaillard, 2009); Reverdin et al., 2002; Reverdin et al., 2007

Longer time series

(feasible in NE subpolar gyre with some data adjustments over the last 120 years)
Reverdin et al., 2010



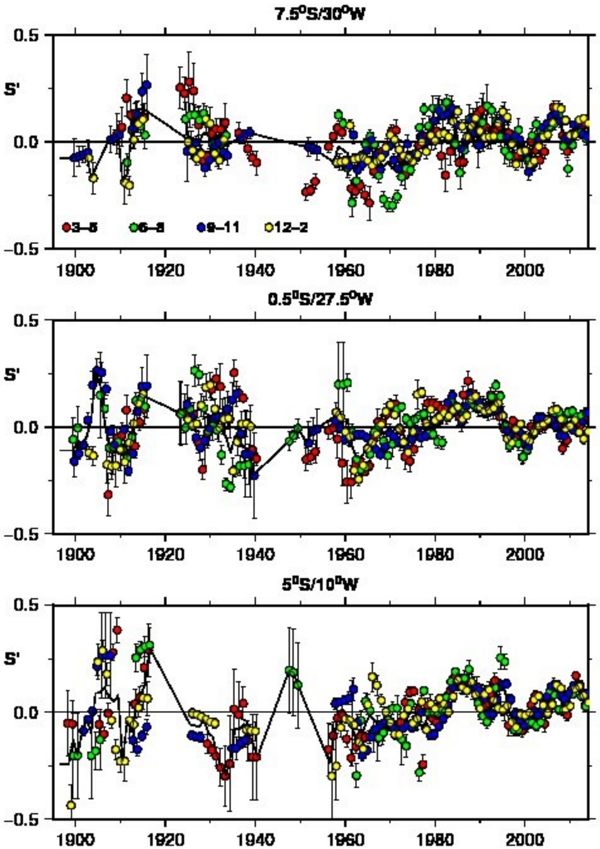


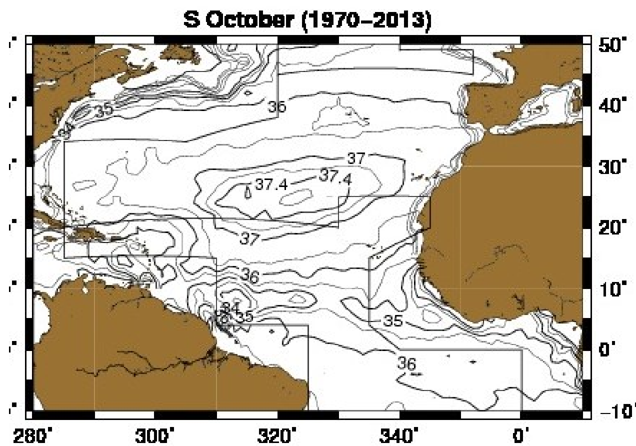


T and S correlated, but present also differences
Low-frequency S presents weak seasonal dependency related to modulation of westerlies (NAO) with 0-4 years lag (0.63)
Studies on the 1990s transition indicates that in winter it is related mostly to changes in ocean circulation/ inputs to the gyre (and E-P)

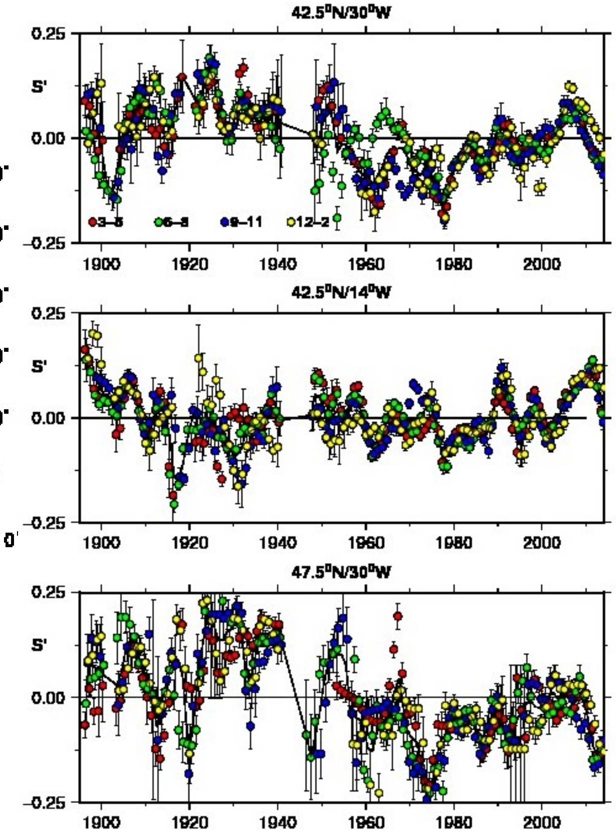
Further south

The worse sampling



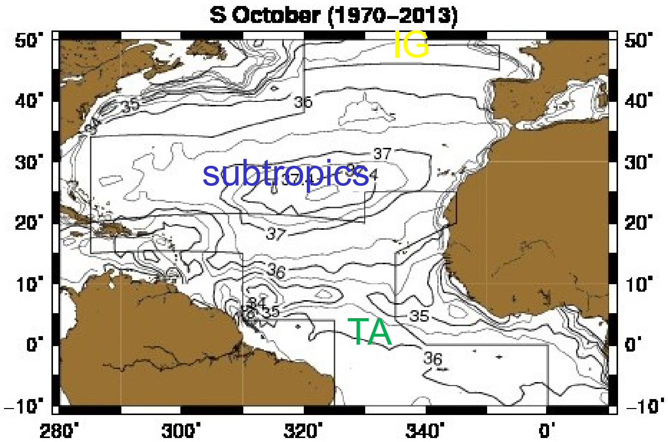


Better sampling further north
But gaps remain

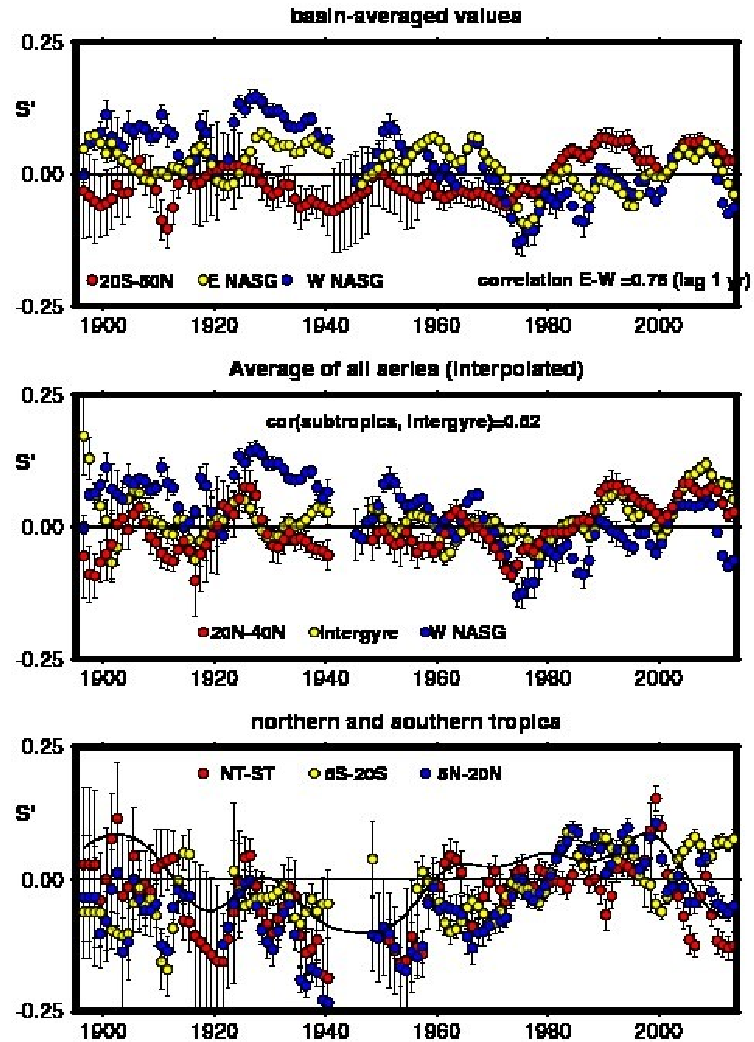


In all cases: issues of corrections/qualification of data (particularly in the 1920s) (requires adjustment of data)
There is often a need to bin in 'big' boxes (and interannual smoothing + averaging different seasons)

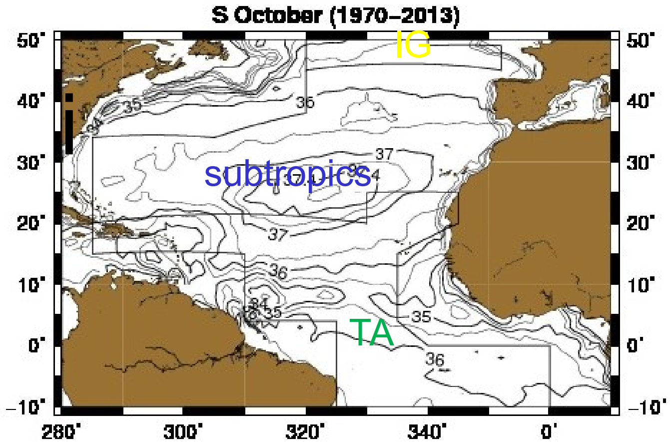
LF variability



LF: < 18 years large part of spatially-averaged*signals
(s twice than for 6-18 yrs band; Except IG)
Tropics, subtropics+IG, and Subpolar gyre have loosely connected LF variability;
But are we mixing AMO natural Variability and anthropogenic var?

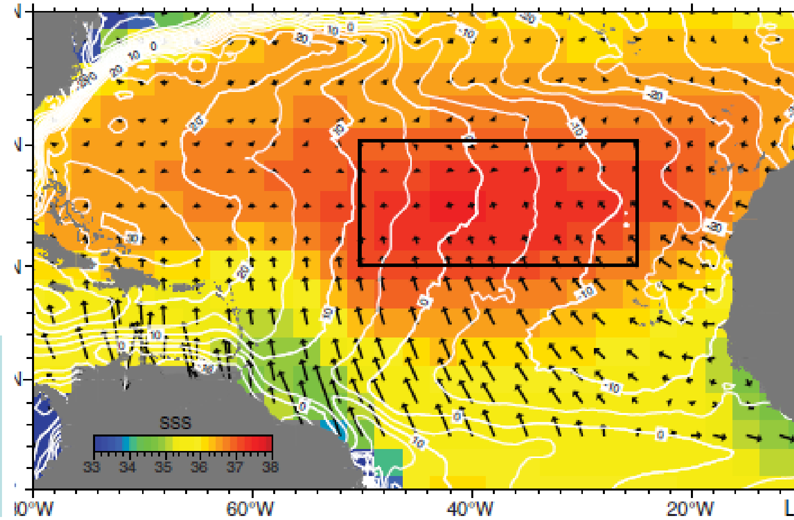


Trends

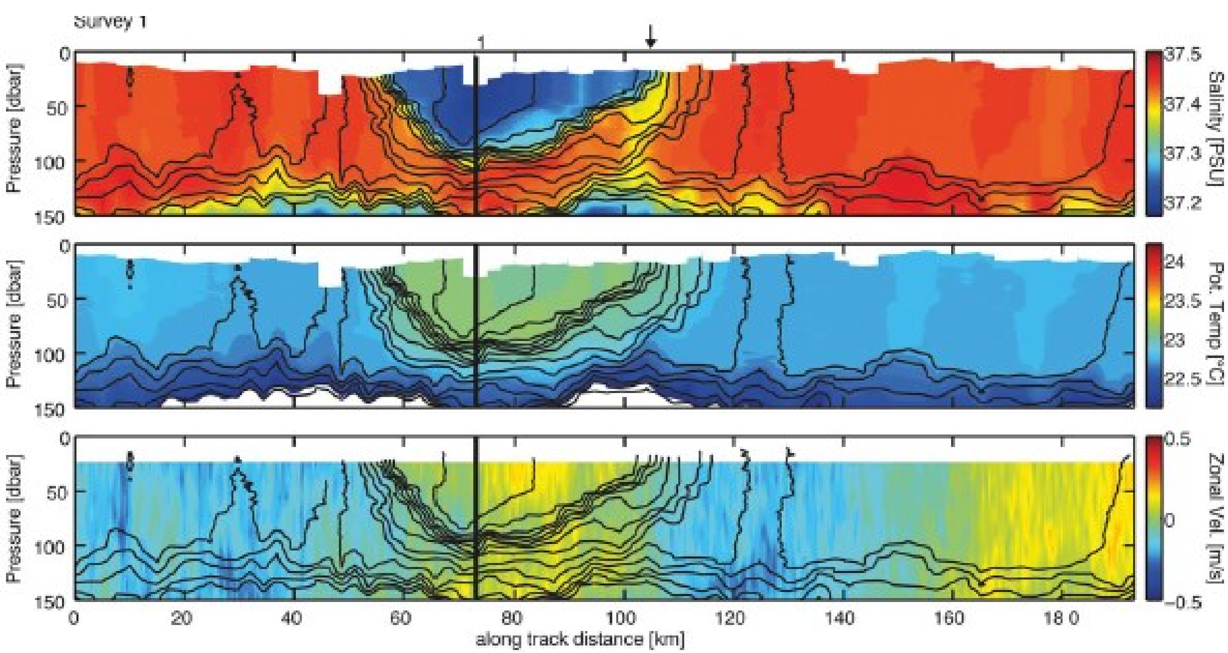


The trends are very different for
Past 40-50 years or for 118 years.
Outside of NASG, trends before 1980
Are not-significant; (in NASG: Negative)
Overall trends positive
STA: 0.08/100yr
Subtropics: 0.07/100yr
IG: 0.017/100yr
Negative in W NASG -0.11 and E NASG -0.038

Meso-scales need to be resolved to study higher frequency variability (seasonal or less) even on the large scales



Examples from SPURS
(1-year survey of NA subtropical gyre)



R. Schmitt
A. Gordon

Feature associated with transport of fresh/warm anomaly from south (Busecke et al., 2014)

Conclusions & Perspectives

- In situ data can be used to have long time series, but issues on some old data remain and cast doubts on some results (large corrections, not always consistent between different seasons)

- Atlantic basin-scale SSS trends over the last 118 years, but not in subpolar gyre. Mostly post-1970

- Data density high enough to investigate spatial patterns of low frequency variability in the last 10y on seasonal time scales and from surface to 2000-m depth.